(Submitted in June of 2005 for the 8th U.S. National Conference on Earthquake Engineering.)

Performance of Mainshock-Damaged Buildings in the Aftershock Environment

Gee Liek Yeo, Nicolas Luco, and C. Allin Cornell

ABSTRACT

We propose a methodology to quantify the performance of mainshock-damaged buildings under different levels of ground shaking caused by potential aftershocks. In the aftershock environment, the frequency of aftershocks capable of incremental damage to an already mainshock-damaged building is greatly increased, and there may be insufficient time to repair the mainshock-damaged building to the original intact state because of reduced availability of manpower resources in the post-mainshock emergency situation. Aftershocks (implicitly or explicitly) affect evacuation decisions regarding (possibly) mainshock-damaged buildings. Because of the inferred life safety threat in occupying a damaged building that may have less resistance to potential aftershock ground shaking, it is important to be able to assess the capacity of mainshock-damaged buildings, in probabilistic terms. Quantifying the probability that a mainshock-damaged building will be incrementally damaged due to the occurrence of an aftershock thus poses a challenge to current structural engineering analysis capabilities. A procedure based on back-to-back nonlinear dynamic time-history analysis of a structure (Luco et al. 2004) is extended to quantify the (transition) probabilities of buildings in different levels of initial mainshock-sustained damage going to worse damage states due to the potential occurrences of aftershocks. Several levels of damage sustained by the structure are defined by associating increasing levels of damage with increasing values of peak roof drift ratios. These transition probabilities are coupled with aftershock ground motion hazard analysis to estimate the likelihood of the structure advancing to various damage states, including collapse, as a function of elapsed post-mainshock time. We illustrate the methodology with single-degree-of-freedom representations of a three-story pre-Northridge steel moment-resisting frame building.